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Cretapenaeus berberus n. gen., n. sp.
(Crustacea, Decapoda, Penaeidae) from the
Late Cretaceous (Cenomanian) of southeastern Morocco

Abstract - An assemblage of macruran decapod crustaceans discovered in the Kem Kem area was collected from the Late Cretaceous (Cenomanian) continental formation of southeastern Morocco and represents the basis for erecting a new genus. The studied specimens are ascribed to the new genus *Cretapenaeus* with *C. berberus* n. sp., as the type species (superfamily Penaeoidea Rafinesque, 1815, family Penaeidae Rafinesque, 1815). As suggested by other faunal elements from the same area, such as molluscs and insects, the decapods may have lived in a freshwater environment, a lake or a pool deposit. Freshwater decapods are very rare in the fossil record, limited to 13 reports from Mesozoic and Cenozoic deposits. Since among the natantians, only the carideans are known to date in this kind of environment, the Morocco penaeids represent the first report of the family Penaeidae in a freshwater habitat.

Key words: Crustacea, Decapoda, Late Cretaceous, Morocco.

Riassunto - *Cretapenaeus berberus* n. gen., n. sp. (Crustacea, Decapoda, Penaeidae) del Cretacico superiore (Cenomaniano) del Marocco sudorientale.

Un campione di crostacei decapodi macruri, rinvenuto nell'area del Kem Kem, è riferibile al Cretacico superiore (Cenomaniano) della formazione continentale del Marocco sudorientale e rappresenta la base per la descrizione di un nuovo genere. Gli esemplari studiati sono ascritti al nuovo genere *Cretapenaeus* con *C. berberus* n. sp. come specie tipo (superfamiglia Penaeoidea Rafinesque, 1815, famiglia Penaeidae Rafinesque, 1815). Come suggerito da altri elementi faunistici rinvenuti nella stessa area, quali molluschi e insetti, i crostacei decapodi sarebbero vissuti in un ambiente d'acqua dolce, quale ad esempio un lago. I decapodi di acqua dolce sono molto rari nel record fossile, limitati a 13 segnalazioni tra Mesozoico e Cenozoico. Visto che tra i natantians solo i caridei sono conosciuti finora in questo tipo di ambiente, i peneidi del Marocco rappresentano la prima segnalazione della famiglia Penaeidae in un ambiente di acqua dolce.

Parole chiave: Crustacea, Decapoda, Cretacico superiore, Marocco.

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Introduction

The studied specimens were originally discovered in 1995, in a clayey horizons of the Kem Kem beds, during a field trip mainly focused on dinosaurs (Sereno *et al.*, 1996). Three other field trips (1999, 2000, and 2002) focused on these clayey horizons resulted in collection of many additional fossils (Fig. 1).

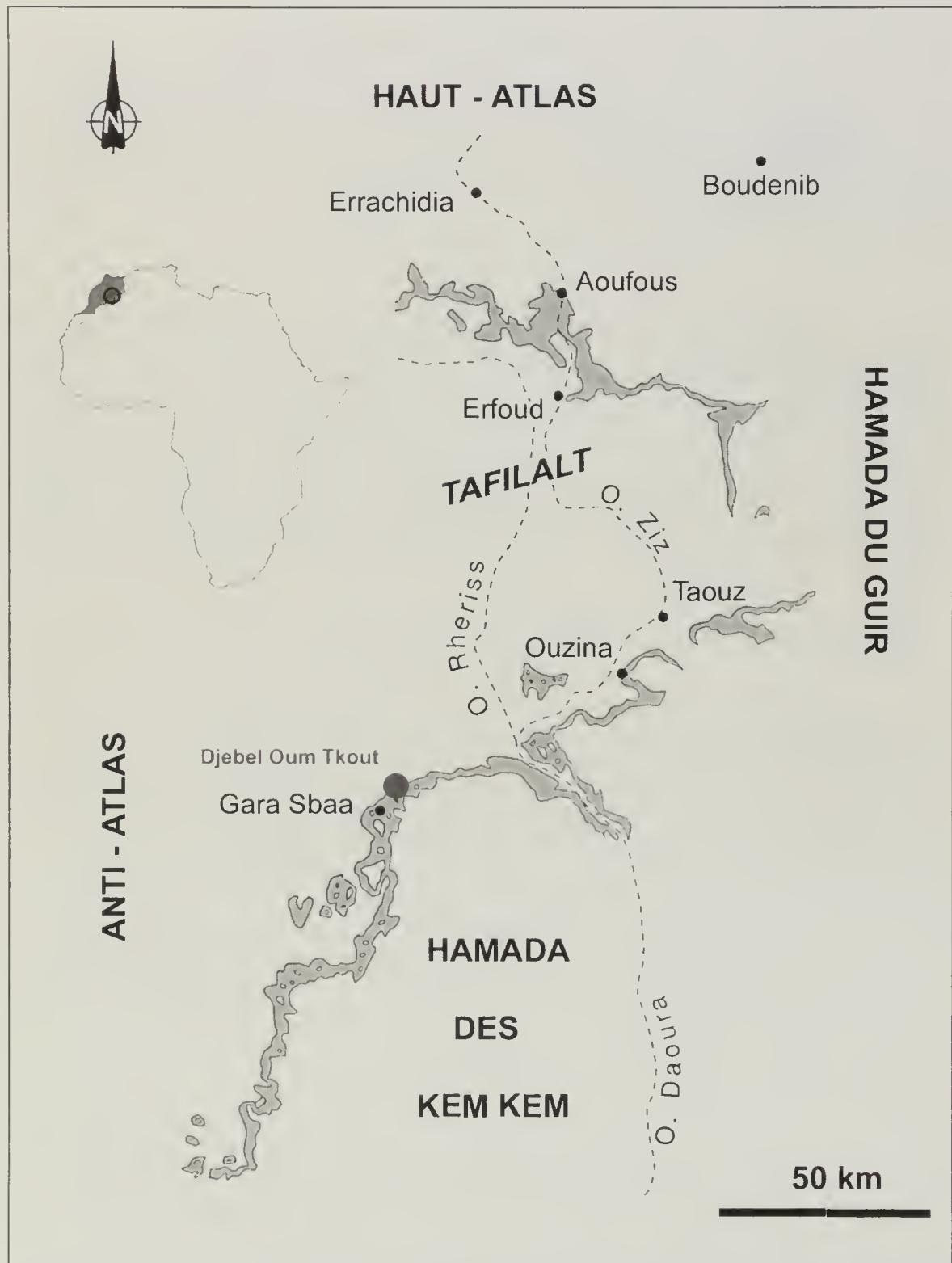


Fig. 1 - Location of the fossiliferous area (Ubicazione dell'area fossilifera).

Geological setting

The Kem Kem beds comprises a succession of red sandstones and mudstones exposed in an area 250 km long in the Tafilalt area, the Hammada of Guir, and the Hammada of Kem Kem in southeastern Morocco. The specimens studied in this note were found in the Djebel Oum Tkout (DOT), southwest of Taouz, 12 km south of Tafraout, close to the Gara Sba locality (Fig. 2).



Fig. 2 - The fossiliferous area where the studied specimens were discovered (L'area fossilifera dove sono stati rinvenuti gli esemplari studiati).

Stratigraphy: the Kem Kem beds (Sereno *et al.*, 1996) or “Infracénomanien” (Clariond, 1933), is formed by two depositional units (Choubert, 1948) (Fig. 3). The thickness of this formation is around 200 m (Lavocat, 1954). The units are nearly equal in thickness. The lower unit lies unconformably on Paleozoic rocks. In this unit, conglomerate, sands, sorted or coarse sandstones were deposited in alluvial fans. Cross beddings is very frequent. The second unit includes sequences of sandstones, detrital channels, clay beds and, on the top, a dinosaur track key bed. The second unit is covered by the Cenomanian-Turonian marine rock transgression. The material studied in this note is from clayey beds at the basement of the second unit (Fig. 4).

CENOMANO-TURONIAN

K E M K E M B E D S

upper unit
lower unit

150

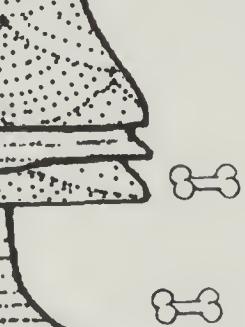
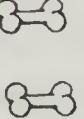
100

50

PALEOZOIC

Lithotypes

[grid pattern]	Paleozoic rock
[white with horizontal lines]	Limestones
[diagonal lines]	crossbeddings
[dotted pattern]	sandstones
[light gray pattern]	sands
[black]	clay



Biogenic structures

[leaf-like symbol]	Plants
[snail shell symbol]	Unionids
[crab-like symbol]	Decapods
[arrow symbol]	Elasmobranchs
[fish symbol]	Actinopterygians
[bone symbol]	Disarticulated bones
[dinosaur track symbol]	Dinosaur tracks

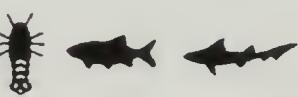


Fig. 3 - Kem Kem beds (Stratigrafia del Kem Kem).



Fig. 4 - Clayey beds in which the studies specimens where discovered (Strati calcarei nei quali sono stati rinvenuti gli esemplari studiati).

Neither radiometric nor magnetostratigraphic testing have provided an age of this formation. Based on distinct, temporally limited vertebrate fossil remains, a Cenomanian age is proposed for the Kem Kem beds (Sereno *et al.*, 1996; Dutheil, 2000).

Palaeontology: palaeontology investigations of the Kem Kem beds have been made since Lavocat (1948). Most of the fossils are disarticulated remains of vertebrates from sands or sandstones. They are represented by elasmobranchs (Dutheil, 2000), actinopterygians (Tabaste, 1963; Dutheil, 2000), actinistians and dipnoi (Tabaste, 1963), turtles (Gmira 1995), pterosaurs (Kellner & Mader, 1997), dinosaurs (Lavocat, 1948; Russell, 1996; Sereno *et al.*, 1996), and crocodiles (Buffetaut, 1994; Larsson & Sidor, 1999).

Clayey beds at the bottom of the second unit of the Kem Kem beds in the Djebel Oum Tkout yielded a spectacular Konservat and Konzentrat Lagerstätten (Dutheil, 1999). In these beds, fossils are articulated and exhibit high level of preservation (biomineralize muscles) (Fig. 5). The flora is represented by gymnosperms and angiosperms. The faunal assemblage is composed by mollusks (unionids), insects (odonatopterans, ephemeropterans, and coleopterans), malacostracans (decapods, isopods), elasmobranchs (Hybodontoidea indet., Acrodontidae indet., Batoidea indet.). The actinopterygian fishes are cladistians (*Serenoichthys kemkemensis* and *Cladistia* indet.), osteoglossiforms, clupeomorphs (Paraclupeidae and Clupeomorpha indet.), ostariophysans and acanthomorphs, and some actinopterygians with indeterminate phylogenetical positions (*Spinocaudichthys oumtkoutensis*, *Diplospondichthys moreau*).

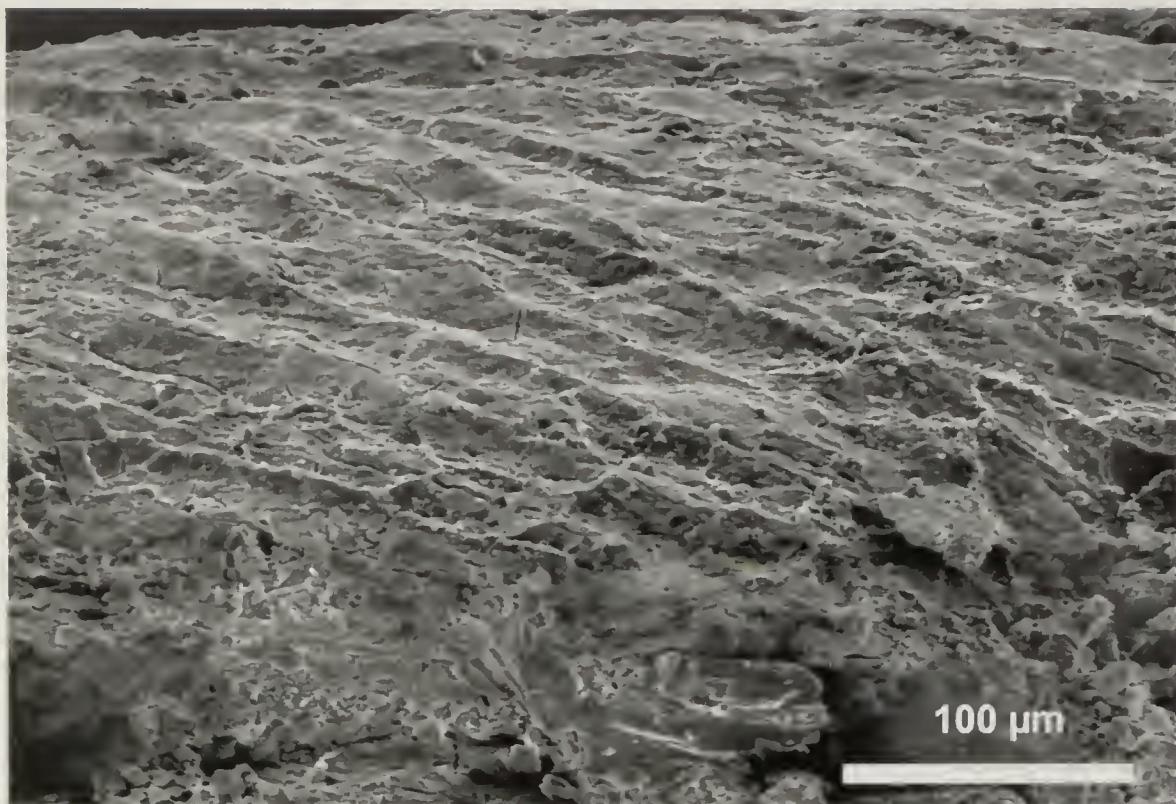


Fig. 5 - Muscular fibres preserved in abdominal somite II of the holotype (Fibre muscolari conservate nel somite addominale II dell'olotipo).

Paleoenvironment: the presence of unionids and larvae of odonatopterans and ephemeropterans indicates a peaceful freshwater habitat comparable to a small lake or a pool (Fig. 6). Most of the taxa derive from a freshwater or terrestrial habitat and there is no evidence of marine organisms. Mudcracks are present. The flora and fish faunal assemblages suggest a freshwater environment.



Fig. 6 - Freshwater odonatopteran insect discovered in the fossiliferous area (Insetto odonato rinvenuto nell'area fossilifera).

Freshwater fossil decapod crustaceans

Freshwater decapod crustaceans are rare in the fossil record, limited to 13 reports, five from the Mesozoic and eight from the Cenozoic.

Mesozoic

Enoploclytia porteri Miller & Ash, 1988, Late Triassic (Carnian) of Chinle Formation (Petrified Forest National Park, Arizona, United States) (Miller & Ash, 1988).

Palaeocambarus licenti (Van Straelen, 1928) and *Cricoidoscelosus aethus* Taylor et al., 1999, Late Jurassic of Jehol Group (Liaoning province – China) (Taylor et al., 1999).

Beurlenia araripensis Martins-Neto & Mezzalira, 1991a, and *Paleomattea deliciosa* Maisey & Da Gloria, 1995, Early Cretaceous (late Aptian – early Albian) of Santana Formation (Brazil) (Martins-Neto & Mezzalira, 1991a; Maisey & Da Gloria, 1995).

Delclosia martinelli Rabadà, 1993, and *Australopotamobius llopisi* (Via Boada, 1971), Early Cretaceous (early Barremian) of Las Hoyas (Cuenca, Spain) (Rabadà, 1993; Garassino, 1997).

Yongjicaris zhejiangensis Garassino et al., 2002, Early Cretaceous (Barremian) of Zhejiang Province (China) (Garassino et al., 2002).

Cenozoic

Pacifastacus chenoderma (Cope, 1871), Miocene of Payette Formation (Idaho and Oregon, United States) (Rathbun, 1929).

Bechleja inopinata Houša, 1956, Oligocene of Czech Republic (Houša, 1956).

Bechleja rostrata Feldmann et al., 1981, and *Procambarus (Astrocambarus) primaevus* (Packard, 1880), Eocene of Green River Formation (Wyoming, United States) (Feldmann et al., 1981).

Bechleja bahiaensis (Beurlen, 1950) and *B. robusta* Martins-Neto & Mezzalira, 1991b, Oligocene of Tremembé Formation (San Paulo State, Brazil) (Beurlen, 1950; Martins-Neto & Mezzalira, 1991b; Martins-Neto, 1998).

Lammastacus longirostris Aguirre-Urreta, 1992, Oligocene of Ñirihuau Formation (Patagonia, Argentina) (Aguirre-Urreta, 1992).

Paranephrops fordyei Feldmann, 1994, Miocene of Manuherikia Group (Central Otago, New Zealand) (Feldmann, 1994).

Palaeomon mortuus Smirnov, 1929, *Pasiphea mortua* Smirnov, 1929, and *Crangon miocenicus* (Garassino & Teruzzi, 1996), Miocene of N Caucasus (Russia) (Smirnov, 1929; Garassino & Teruzzi, 2001).

Materials

The studied specimens are preserved in clayey beds and flattened on the layer surface in lateral and ventral view. Their preparation was made easy as a result of the softness of the surrounding rock.

All specimens (34 in all) belong to the same species and are ascribed to *Cretapenaeus* n. gen. with *C. berberus* n. gen., n. sp. (superfamily Penaeoidea Rafinesque, 1815, family Penaeidae Rafinesque, 1815) designated the type species.

Twenty-six very small specimens were not included in the studied sample because it is very difficult to observe morphological characters in order to justify their description.

Acronyms. MNHN: Muséum national d'Histoire naturelle, Paris; MSNM: Museo Civico di Storia Naturale, Milano.

Systematic Palaeontology

Superfamily Penaeoidea Rafinesque, 1815

Family Penaeidae Rafinesque, 1815

Genus *Cretapenaeus* nov.

Diagnosis: integument glabrous; very elongate rostrum armed with six dorsal teeth; epigastric tooth; cervical groove weak; hepatic and branchiocardiac grooves absent; antennular flagella longer than antennular peduncle; pereiopod V slender and very elongate, longer than preceding ones; telson unarmed; uropodal exopod without diaeresis.

Etymology: from Cretaceous, geological age of the studied specimens.

Type species: *Cretapenaeus berberus* n. sp.

Description: as for type species.

Cretapenaeus berberus n. sp.

Figs. 7-11

Diagnosis: as for genus.

Etymology: from Berber people living in Morocco.

Holotype: MNHN A24633.

Paratypes: MNHN A24634, A24635, A24636; MSNM i26604, i26605, i26606.

Type locality: Djebel Oum Tkout.

Stratigraphic range: Late Cretaceous (Cenomanian).

Occurrence and measurements: 34 incomplete and complete specimens in lateral and ventral views, 2 to 10 cm long. MNHN A24633, A24634, A24635, A24636, MSNM i26604, i26605, i26606. The other specimens including in the studied sample have the same catalogue number MNHN A24638.

Description: medium-sized penaeid with smooth exoskeleton.

Carapace. Subrectangular carapace flattened laterally. Very elongate rostrum with six dorsal teeth directed forward. Strong epigastric tooth. Posterior margin with a weak marginal carina. Weak cervical groove. Hepatic and branchiocardiac grooves absent. Antennal spine absent. Narrow ocular incision. Weak antennal and pterigostomial angles.

Abdomen. Subrectangular somites I-VI of equal length. Smooth tergal surface. Triangular telson unarmed with pointed distal extremity. Uropodal endopod and exopod longer than telson. Uropodal exopod with a weak median longitudinal carina and without diaeresis.

Cephalic appendages. Large eye with a short eyestalk. 3rd maxilliped not preserved. Antennular peduncle as long as the rostrum. Antennular flagella longer than antennular peduncle. Antennular flagella almost as long as antennal flagella.

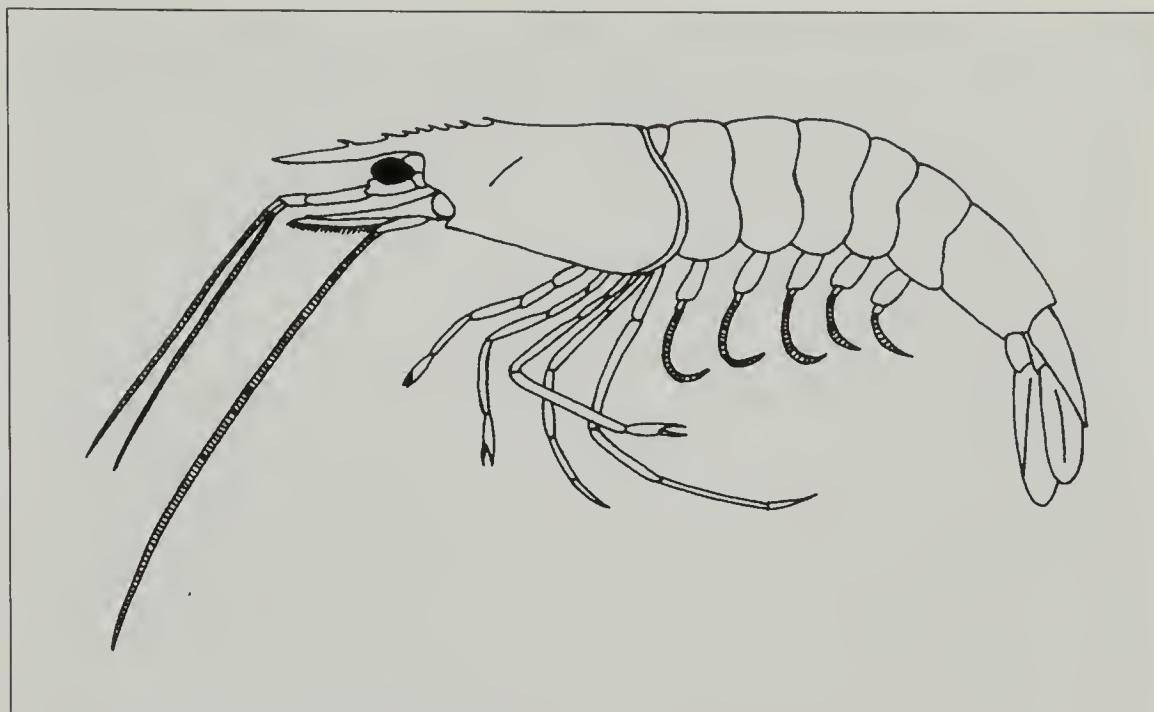


Fig. 7 - *Cretapenaeus berberus* n. gen., n. sp., reconstruction (ricostruzione).



Fig. 8 - *Cretapenaeus berberus* n. gen., n. sp., holotype (olotipo), n. cat. MNHN A26633 (natural size) (grandezza naturale).



Fig. 9 - *Cretapenaeus berberus* n. gen., n. sp., paratype (paratipo), n. cat. MNHN A24634 (x 4).



Fig. 10 - *Cretapenaeus berberus* n. gen., n. sp., paratype (paratipo), n. cat. MNHN A24636 (x 2.5).



Fig. 11 - *Cretapenaeus berberus* n. gen., n. sp., n. cat. MNHN A24651, detail of cephalic appendages (dettaglio delle appendici caudali) (x 5).

Thoracic appendages. Pereiopods I-III chelate with thin and elongate segments. Chelae increasing length from I to III. Pereiopod V slender and very elongate, longer than preceding ones.

Abdominal appendages. Pleopods bi-ramose, with robust and very elongate flagellae of equal size.

Discussion. Pérez Farfante & Kensley (1997) reported the main morphological characters of the family Penaeidae Rafinesque, 1815: body compressed, comparatively slender; rostrum well developed, extending to or beyond distal margin of eye, armed with dorsal and sometimes also with ventral teeth; carapace without postorbital spine; antennal and hepatic spines usually present; cervical groove ending well ventral to dorsal midline; posterior abdominal somites carinate; telson sharply pointed, with or without lateral spines.

The good state of preservation of the studied specimens allows recognition of many

of the above-mentioned characters in order to justify their ascription to this family.

The family Penaeidae is represented in the fossil record with 25 genera from Mesozoic and Cenozoic deposits: *Acauthochirana* Strand, 1926 (Late Jurassic/Late Cretaceous – Germany and Lebanon), *Albertoppelia* Schweigert & Garassino, 2004 (Late Jurassic – Germany), *Ambilobeia* Garassino & Pasini, 2002 (Early Triassic – Madagascar), *Antrimpos* Münster, 1839 (Late Triassic/ Late Jurassic – Europe), *Bylgia* Münster, 1839 (Late Jurassic – Germany), *Bombur* Münster, 1839 (Late Triassic/Late Jurassic – Europe and United States), *Carinacaris* Garassino, 1994 (Late Cretaceous – Lebanon), *Drobna* Münster, 1839 (Late Jurassic – Germany), *Hakelocaris* Garassino, 1994 (Late Cretaceous – Lebanon), *Koelga* Münster, 1839 (Late Jurassic – Germany), *Ifasya* Garassino & Teruzzi, 1995 (Early Triassic – Madagascar), *Libanocaris* Garassino, 1994 (Late Cretaceous – Lebanon), *Longichela* Garassino & Teruzzi, 1993 (Late Triassic – Italy), *Macropenaeus* Garassino, 1994 (Late Cretaceous – Lebanon), *Microchela* Garassino, 1994 (Late Cretaceous – Lebanon), *Micropenaeus* Bravi & Garassino (Early Cretaceous – Italy), *Penaeus* Fabricius, 1798 (Early Cretaceous/Recent – cosmopolite), *Pseudobombur* Secretan, 1975 (middle Lutetian – Italy), *Pseudodusa* Schweigert & Garassino, 2004 (Late Jurassic – Germany), *Rauna* Münster, 1839 (Late Jurassic – Germany), *Rhodanicaris* Van Straelen, 1925 (Middle Jurassic – France), *Satyrocaris* Garassino & Teruzzi, 1993 (Late Triassic – Italy), *Sicyonia* H. Milne Edwards, 1830 (Late Cretaceous – Germany).

Bombur, *Drobna*, *Dusa*, *Micropenaeus*, and *Satyrocaris*, having a short rostrum, are excluded from the comparison with the new genus. *Rauna*, poorly preserved, is excluded from the comparison, too.

The elongate rostrum with six dorsal teeth distinguishes the new genus from *Koelga* having a rostrum with one ventral tooth.

Even though the other genera of the family Penaeidae have a long rostrum with a variable number of dorsal teeth, the rostrum is not so elongate as in *Cretapenaeus* n. gen. Moreover, the very elongate pereiopod V is typical of the new genus, not observable in the other fossil genera. So we justify the erection of this new genus by these two morphological characters: the very elongate rostrum and the very elongate pereiopod V.

Among the living species belonging to the family Penaeidae, rostral morphology in *Atypopenaeus* Alcock, 1905, is close to that seen in the studied specimens, with dentate dorsal margin of the rostrum. Additional similarity between *Cretapenaeus* n. gen. and *Atypopenaeus* include the antennular peduncle as long as the rostrum, the antennular flagella longer than antennular peduncle, the antennular flagella almost as long as antennal flagella, and the very elongate pereiopod V. This suggests that *Cretapenaeus* n. gen. could represent an extinct penaeid closely related to the living *Atypopenaeus*.

Today, the carideans are the only natantians known in freshwater environments from Mesozoic and Cenozoic deposits (Martins-Neto & Mezzalira, 1991a, b; Maisey & Da Gloria, 1995; Rabadà, 1993; Garassino, 1997; Houša, 1956; Feldmann *et al.*, 1981; Beurlen, 1950; Smirnov, 1929; Garassino & Teruzzi, 2001). So, the discovery of *Cretapenaeus* n. gen. in the Kem Kem area in southern Morocco represents the first record of the family Penaeidae in a freshwater habitat.

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